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"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

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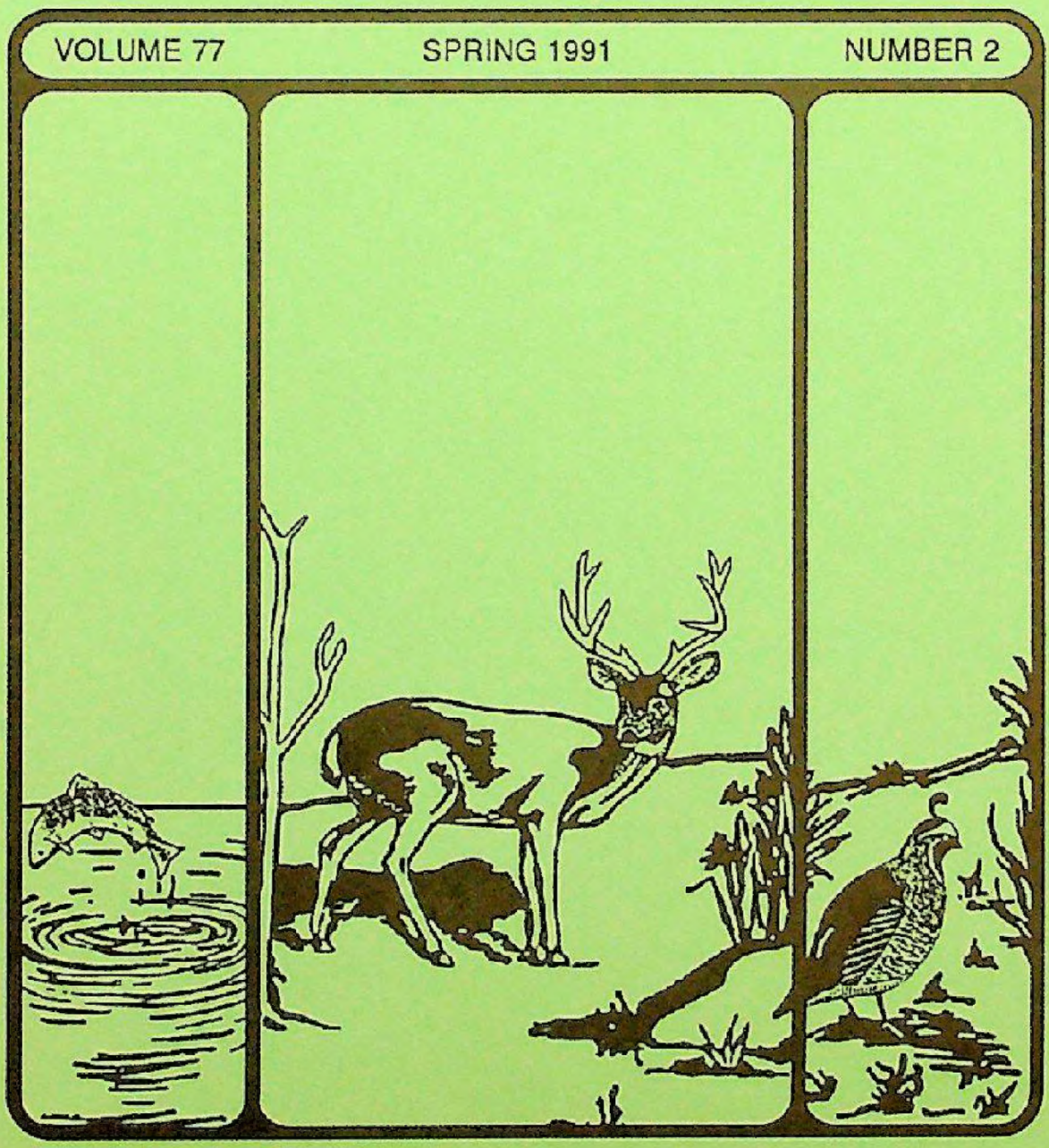

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Please direct correspondence to:

Dr. Eric R. Loft, Editor in Chief
California Fish and Game
1416 Ninth Street
Sacramento, California 95814

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MAMMAL MORTALITY AT ARIZONA, CALIFORNIA, AND NEVADA GOLD MINES USING CYANIDE EXTRACTION

DONALD R. CLARK, JR.
U.S. Fish and Wildlife Service
Patuxent Wildlife Research Center
Laurel, MD 20708
and
ROGER L. HOTHEM
U.S. Fish and Wildlife Service
Patuxent Wildlife Research Center
Pacific Coast Research Group
c/o Department of Wildlife and Fisheries Biology
University of California, Davis
Davis, CA 95616

Five-hundred nineteen mammals were reported dead at cyanide-extraction gold mines in Arizona, California, and Nevada from 1984 through 1989. Most numerous were rodents (34.9%) and bats (33.7%); "bat" was the most often reported category among 24 species or species groups. There are an estimated 160 cyanide-extraction gold mines in these three states, and the number is increasing. Ten mammal species listed as endangered, threatened, rare, protected, or species of special concern are known to have cyanide-extraction gold mines within their geographic ranges.

Modern gold mining uses sodium cyanide to extract the metal from ore. During this process, cyanide solutions are usually stored in ponds and they collect in small pools on tops of ore piles, known as "heaps", where they may attract and kill wildlife. Concern has centered on migratory birds because they have died in the largest numbers and because the Migratory Bird Treaty Act [16 U.S.C. 703-711] makes it illegal to kill birds in this way (Hallock 1990). Recently, in the first prosecution of a gold mine, a fine and restitution fee were assessed for deaths of 1,459 migratory birds during 1988 (U.S. Fish and Wildlife Service 1990*a*). Some mines have netted ponds to exclude birds (e.g. Sturgess et al. 1989, Schroder and Burns 1990), some have decreased concentrations of cyanide in their solutions, others detoxify solutions before ponding, and one mine has covered its ponds with plastic sheeting. However, the present gold boom, based on cyanide technology, will probably last well into the twenty-first century (Knudson 1990*a*), and wildlife mortality is continuing.

A diversity of mammals has also died at these mines, but these deaths have received much less attention than migratory birds. Our objective was to summarize the mortality data available for mammals with special reference to species whose futures are of official concern.

MINING PROCESS AND STUDY METHODS

Gold dissolves in cyanide solution. This allows both extraction of gold particles too small to be seen and profitable mining of ores that average only 0.05 ounces of gold per ton (1.6 parts per million, ppm). The procedures for gold removal are usually (1) heap leaching or (2) carbon-in-pulp vat leaching. In heap leaching, ore is pulverized and deposited in flat-topped heaps containing up to 2.5 million tons. Beneath the heap a heavy plastic layer is placed on a slightly sloping surface. A caustic solution of sodium cyanide is applied with sprinklers or by drip irrigation on top of the heap and collected at the bottom by drainage canals or pipes which conduct it to a "pregnant pond." This gold-bearing solution is passed through a series of carbon filters onto which the gold adsorbs. The gold is flushed from the carbon with a stronger caustic-cyanide solution and then electroplated onto steel wool which is smelted to obtain the gold. After the gold is removed by the carbon, the cyanide solution is sent to a "barren pond" where it is recharged with cyanide and lime before being returned to the heap. In the carbon-in-pulp mill process, the pulverized ore, cyanide solution, and carbon are combined in a large steel vat. After leaching, the spent ore and cyanide solution are sluiced to a "mill tailings" pond, and the carbon is retained for removal of the gold, as described above. The cyanide solution is decanted from the mill tailings, recharged, and returned to the vat. Mining procedures are described in detail by Cole and Kirkpatrick (1983) and Silva (1988).

Wildlife mortalities may occur wherever there is open cyanide solution, in storage ponds, in puddles on tops of heaps, or flowing in channels along the base of a heap to a pregnant pond. Cyanide concentrations as high as 770 ppm (U.S. Fish and Wildlife Service 1990*a*) or even 9,000 ppm (Silva 1988) have been recorded; however, 200-300 ppm is probably typical of solutions prepared for leaching. Heap leach ponds average about 0.5 ha, whereas mill tailings ponds may be 40 ha or more (Hallock 1990).

Mortality data were obtained from the Nevada State Department of Wildlife, from area offices of the U.S. Bureau of Land Management (BLM) in Arizona and California, and from the California state BLM office. Data are complete from the beginning of records in 1980 through 1989. These data were provided voluntarily by individual mines and animal identifications are those of mine workers. A few mortalities recorded only as "other animal" were excluded from consideration, and mortalities not assignable to a specific year were omitted from "by year" lists.

Federal and state lists were used to identify endangered, threatened, rare or protected mammal species, or mammal species of special concern (ETRPSC species; Nevada Board of Fish and Game Commissioners 1984, Williams 1986, Arizona Game and Fish Department 1988, California Department of Fish and Game 1990, U.S. Fish and Wildlife Service 1990*b*). Geographic range information on mammals for California was taken from Jameson and Peeters (1988). Arizona and Nevada range information was taken from Burt and Grossenheider (1976) and Whitaker (1980).

RESULTS

The distribution of cyanide extraction gold mines in Arizona, California, and Nevada is outlined in Figure 1. Figure 1 indicates the general location of 97 large mines, most of which were on public land. The total number of gold mines was estimated at "more than 160" for the three states (Knudson 1989), and "between 110 and 130 active mines with possibly 300 individual ponds that contained cyanide" for Nevada alone (Hallock 1990).

Thousands of vertebrates have died at mine sites (Table 1). Total reported bird deaths are an order of magnitude greater than mammal deaths, and mammal deaths are an order of magnitude greater than reptile or amphibian deaths. Total reported wildlife deaths in Nevada are an order of magnitude greater than reported in California or Arizona.

The largest mammal category reported is "bat" (Table 2). In the three largest kills, Cyprus Copperstone mine in Arizona reported 51 bats killed during August-October 1988, Coeur-Rochester mine in Nevada reported 32 bats in the third quarter of 1987, and Green Springs mine in Nevada reported 12 bats in the fourth quarter of 1988. The coyote appears to be a particularly susceptible species. By Order, rodents and bats were the most commonly reported mammals. All reported carnivores were identifable to Family and included: 45 canids (coyotes, foxes, and dogs), 9 mustelids (skunks, badgers, and a weasel), and 2 felids (domestic cats). Numbers of mammals

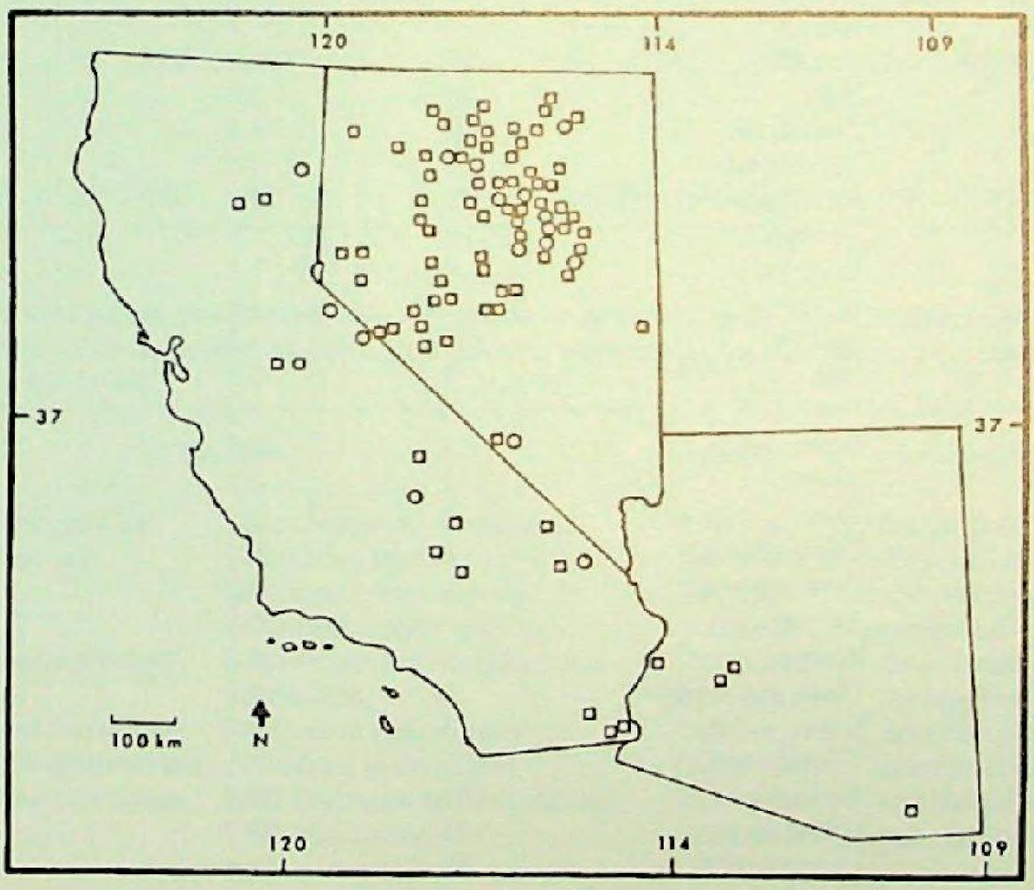

Figure 1. Locations of active (square) and proposed (circle) cyanide extraction gold mines in Arizona, California, and Nevada. Locations adapted from Wilderness Society (1989) and Arizona Department of Mines and Mineral Resources (1990).

Table 1. Vertebrate mortality and percentage of birds, reptiles, and amphibians reported at cyanide extraction gold mines in Arizona, California, and Nevada from 1980 through 1989.

State	No. of mines	Mammals	Birds	Reptiles	Amphibians	Total
Arizona	1	52	357	0	0	409
		12.7%	87.3%			
California	11	34	606	14	0	654
		5.2%	92.7%	2.1%		
Nevada	63	433	6,034	24	55	6,546
		6.6%	92.2%	0.4%	0.8%	
Total	75	519	6,997	38	55	7,609
		6.8%	92.0%	0.5%	0.7%	

Table 2. Mammal mortalities ($n = 519$) by species, species group, or Order as reported by 42 mines in Arizona, California, and Nevada from 1980 through 1989. Another 33 mines reported no mammal deaths. All mammal deaths occurred from 1984 through 1989.

Group	Number	Percent
Bat	174	33.5
Rodent	87	16.8
Mouse	59	11.4
Rabbit	35	6.7
Coyote	27	5.2
Deer	26	5.0
Chipmunk	23	4.4
Jackrabbit	21	4.0
Mammal (unspecified)	20	3.8
Squirrel	8	1.5
Gray fox	7	1.3
Kit fox	6	1.2
Badger	6	1.2
Rat	3	0.6
Fox	3	0.6
Cottontail	3	0.6
Skunk	2	0.4
Dog	2	0.4
Domestic cat	2	0.4
Free-tailed bat	1	0.2
Beaver	1	0.2
Weasel	1	0.2
Black-tailed deer	1	0.2
Cow	1	0.2
Totals by Order		
Rodentia	181	34.9
Chiroptera	175	33.7
Lagomorpha	59	11.4
Carnivora	56	10.8
Artiodactyla	28	5.4
Mammal (unspecified)	20	3.8

and birds reported dead peaked in 1988 (Table 3). From 1986 through 1989 the number of mortalities reported per mine declined steadily while the number of mines increased.

Comparison of the area where mines are located (Fig. 1) with the geographic ranges of ETRPSC mammal species shows 10 species potentially affected (Table 4).

DISCUSSION AND CONCLUSIONS

Most of the identifications are not to species level (Table 2), and this precludes accurate assessment of the impact on ETRPSC mammal species. For example, there could easily be specimens of ETRPSC species among the 174 reported bat mortalities. A California population of Townsend's big-eared bat, *Plecotus townsendii*, may have been extirpated by cyanide at a nearby mine (P. Brown, pers. comm.).

Table 3. Bird and mammal deaths reported each year from 1980 through 1989 at cyanide gold mines in Arizona, California, and Nevada.

	Year									
	80	81	82	83	84	85	86	87	88	89
No. mines reporting	1	1	1	0	2	2	10	29	57	65
Deaths/mine	20	522	89	-	74	24	144	50	42	20
Birds	20	522	89	-	148	46	1,298	1,369	2,204	1,204
Mammals	0	0	0	-	1	1	137	85	185	104
Total	20	522	89	-	149	47	1,435	1,454	2,389	1,308

Table 4. Endangered, threatened, rare, or protected mammal species, or mammal species of special concern that have cyanide extraction gold mines in that part of their geographic range within the listing political unit.

Species		List(s)	Category
Lesser long-nosed bat	(*Leptonycteris curasoae*)	Arizona[1], U.S.[2]	endangered
Long-tongued bat	(*Choeronycteris mexicana*)	Arizona[1]	threatened
Spotted bat	(*Euderma maculatum*)	Nevada[3]	protected-rare
Pika	(*Ochotona princeps*)	Nevada[3]	protected
Mohave ground squirrel	(*Spermophilus mohavensis*)	California[4]	threatened
Wolverine	(*Gulo gulo*)	California[4]	threatened
California leaf-nosed bat	(*Macrotus californicus*)	California[5]	special concern
Townsend's big-eared bat	(*Plecotus townsendii*)	California[5]	special concern
Pocketed free-tailed bat	(*Nyctinomops femorosaccus*)	California[5]	special concern
Badger	(*Taxidea taxus*)	California[5]	special concern

[1]Arizona Game and Fish Department (1988); [2]U.S. Fish and Wildlife Service (1990*b*); [3]Nevada Board of Fish and Game Commissioners (1984); [4]California Department of Fish and Game (1990); [5]Williams (1986)

Another concern is that the reported mortalities may represent only a minor portion of the total. There are three basic reasons why this is probably true. First, reporting requirements vary by State and by whether the mine is on BLM or private land; thus many mines have not been obliged to report.

Second, the counts and species identifications are made by mine personnel who have reason to be biased in favor of under-reporting total deaths and not reporting deaths of known ETRPSC species. Mines sometimes begin reporting mortalities only after authorities are alerted to the problem by an anonymous source (e.g., Daniels 1988). A federal investigator stated that total cyanide mortalities could be 5-10 times higher than reported (Knudson 1990*b*). A golden eagle, *Aquila chrysaetos*, was seen flying down to a cyanide pond (Laycock 1989), and a former state biologist believes that bald eagles, *Haliaeetus leucocephalus*, which are endangered have died at cyanide ponds (Knudson 1989).

A third reason is that many wildlife deaths may occur away from cyanide solutions. To date, searches for and counts of dead animals have been limited to immediate mine sites, and wildlife that escapes from these sites is assumed to be unharmed. However, on 4 April 1989 a red-breasted merganser, *Mergus serrator*, was found dead 20 km NNE of Cyprus Copperstone mine (the nearest known source of cyanide) in western Arizona. Pectoral muscle tissue from this bird tested positive for cyanide when analyzed at the Veterinary Diagnostic Laboratory, University of Arizona, Tucson (J. Keeler, U.S. Fish and Wildlife Service, Yuma, pers. comm.). The amount of such mortality away from cyanide solutions is unknown, but a mechanism by which it might happen involves weak-acid-dissociable (WAD) cyanide compounds. Cyanide bound to certain elements, commonly copper, is dissociable in weak acids such as stomach acid. Thus an animal might drink cyanide solutions and avoid immediate death—if the level of free cyanide is low enough—but die later when additional cyanide is liberated in its stomach by the acid. This possible mechanism needs to be studied. Hallock (1990) points out that others have claimed cyanide at or below 50 ppm is "safe" to wildlife, but there are no data to support this claim. A high proportion of WAD cyanide could increase the apparent safety of a solution as judged from mortality at the mine.

A final concern is that even though we have identified 10 ETRPSC mammal species as potentially at risk, the list might be longer if locations of all open cyanide waters could be determined.

Because the cyanide ponds we have visited appear totally abiotic, we assume that wildlife deaths are due to drinking of cyanide solution. However, scavenging birds, mammals, and reptiles may be exposed through ingestion of cyanide-poisoned wildlife they find at or near ponds.

Mines are constantly changing and the total number is increasing (Hallock 1990). Because mine life spans may be short (<10 years), mine closings are frequent. Some mines are in the process of netting their ponds, or reducing the cyanide concentrations used, or changing from recycling cyanide solutions to detoxifying them. Other mines are using ineffective techniques such as hazing, noise makers, and colored flagging to try to reduce wildlife mortality. A given mine may phase out certain ponds and

build others, or a mine may add a milling facility to its heap leach operation and build tailings ponds. Rainfall can change cyanide concentrations in the same pond from day to day.

The declining number of mortalities per mine (Table 4) may be due to increased efforts by mines to protect wildlife, or it may be due to reduced reporting based on fear of legal reprisals, or it could be a combination of both factors. More worrisome is the possibility that local, non-migratory wildlife populations may have been reduced enough by cyanide solutions to contribute to a long-term decline in total observed mortalities.

If wildlife mortality by cyanide extraction mines is to be prevented, established mines must be required to keep cyanide solutions in closed containers, cover ponds and ditches containing cyanide solution with netting or floating plastic sheeting, or detoxify. Similarly, new mines must initiate these procedures before cyanide solutions are created. Cypress Copperstone mine has extensive experience in developing successful netting techniques (Schroder and Burns 1990). Mesquite mine in extreme southern California has ponds covered with plastic sheeting. Detoxification must be done in ways that do not leave WAD cyanides available to the environment. Hazing and deterrents do not work, are not acceptable (Hallock 1990), and further usage in lieu of proven techniques should not be allowed.

Our observations indicate that pooling on tops of heaps is universal, but methods for, or even attempts at, preventing wildlife access by air are absent. These small pools, measuring up to at least 5 m by 1 m, probably do not attract large flocks of migrating waterfowl as readily as do 40 ha tailings ponds, but they may kill many other birds and many mammals.

Wildlife exists naturally throughout the arid regions where most cyanide extraction mines are located, and migratory routes of birds exist over, or may be altered by the birds to include, cyanide ponds regardless of where they may be built. Both local and migratory wildlife seem able to find cyanide solutions wherever they are placed.

This discussion has dealt only with the impact of cyanide on wildlife. Individual mines often cover thousands of acres and mining companies sometimes lease tens of square miles for possible mining (Wilderness Society 1989). Mining ultimately converts the site into large, flat-topped hills of crushed ore, other crushed rock, or extracted tailings, and huge open pits. Because of this, the habitat that existed on the site is totally destroyed and restoration to anything resembling the original will never happen. Furthermore, the mining process extracts millions of gallons of desert groundwater and this may dry up whatever ephemeral streams occur in the area (Wilderness Society 1989). Any complete accounting of the impact of gold mining on wildlife must also include these factors.

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GENETIC VARIABILITY IN TULE ELK

THOMAS E. KUCERA
Department of Forestry and Resource Management
and Museum of Vertebrate Zoology
University of California
Berkeley, CA 94720

I examined genetic variability at 38 loci in tule elk, *Cervus elaphus nannodes*, using starch-gel electrophoresis. There was no variability in 23 allozymes from blood of 75 individuals from two populations. Using liver and kidney from 24 individuals from one population, there was variation in two of 30 allozymes. The overall proportion of polymorphic loci was 0.053. Tule elk are genetically less variable than conspecifics, probably as a result of the extreme population bottleneck they experienced. Management should emphasize maximizing population size and establishing gene flow among the isolated tule elk populations.

INTRODUCTION

In the early 19th Century, tule elk, California's endemic subspecies of elk, occurred in vast numbers throughout the Central Valley and central coastal areas (McCullough 1969). By 1874, as a result of habitat changes, competition with agriculture and livestock, and market hunting stimulated by the gold rush, tule elk were reduced to as few as 2 survivors. These elk remained in a marsh being drained near the southern Central Valley town of Buttonwillow, and were afforded protection by the landowner. All tule elk today descend from those few individuals. After receiving protection, the tule elk population recovered slowly. In 1895, after 20 years, they numbered only 28. After increasing to about 400 in the early 1920's, the Buttonwillow elk population dropped to 72, perhaps as a result of the development of small farms and the killing of elk by farmers to control agricultural damage caused by elk (McCullough 1969). As a consequence of numerous transplants over the last 85 years, tule elk today number approximately 2,500, and are distributed among 19 herds (California Department of Fish and Game [CDFG] 1985, 1989). These different populations range in size from a few dozen to approximately 600 in the Owens Valley, Inyo County.

If numbers of a large population are severely reduced, or if a new population is founded from a few individuals, and if the population remains small, an important concern is the loss of genetic diversity due to genetic drift (Nei et al. 1975, Franklin 1980, Frankel and Soule' 1981). The amount of this loss as a result of such a "bottleneck" is a function not only of the size of the residual population, but also, and more importantly, the number of generations over which the population remains small. Tule elk were greatly reduced in population size several times, recovered slowly, and repeatedly had new populations founded from the survivors and their

descendants. Thus, tule elk went through an extreme bottleneck, perhaps the most severe known of any large mammal.

Genetic diversity is important because the rate of evolution, and thus the ability to adapt to changing conditions, is a function of the amount of heritable phenotypic variation and the intensity of selection (Fisher 1930). After genetic diversity is lost, its recovery may take from hundreds to tens of thousands of generations once a population has recovered in size, because of low mutation rates (Lande and Barrowclough 1987). Theory predicts that the loss of genetic variation will be greatest in species with a high variation in reproductive success among individuals of one sex. In such species, "effective" population size (N_e) is much smaller than the actual number of individuals (Frankel and Soule' 1981). The highly polygynous elk is such a species (McCullough 1969, Clutton-Brock et al. 1982).

Concerns over loss of genetic diversity, and over inbreeding in small populations, have received empirical justification. Wildt et al. (1987) reported a higher incidence of abnormal spermatozoa and lower testosterone levels in an isolated population of African lions, *Panthera leo*, compared to the unbottlenecked and genetically more variable population from which it was founded. Quattro and Vrijenhoek (1989) found that measures of fitness such as survival and early fecundity were positively associated with genetic variability in populations of the Sonoran topminnow, *Poeciliopsis occidentalis*. Ralls et al. (1979) and Ballou and Ralls (1982) reported the deleterious effects of inbreeding in a variety of zoo ungulates.

Empirical measures of the consequences of a bottleneck on genetic variability in large mammals are rare, due to the absence of information on pre-bottleneck genetics and the poorly known population histories of the animals involved. Dinerstein and McCracken (1990) attributed the high current level of genetic variability in the greater one-horned rhinoceros, *Rhinoceros unicornis*, to the recentness of their bottleneck (within 40 years), their large pre-bottleneck N_e, and their long generation time. Some large mammals of conservation concern, such as the cheetah, *Acinonyx jubatus*, and the northern elephant seal, *Mirounga angustirostra*, exhibit no genetic variation (O'Brien et al. 1985, Bonnell and Selander 1974). Nevertheless, it is unclear what amount of genetic variation each species originally had, and, if a bottleneck occurred, just how severe it was. Alpine ibex, *Capra ibex*, also exhibit low genetic variability, but again, the population history of this species is imprecisely known, and the bottleneck apparently occurred before the 18th Century (Stuwe and Scribner 1989). Thus, the well-documented population history of the tule elk is unusual. Although there is no information on genetic diversity in tule elk prior to their 19th Century bottleneck, some cautious inferences may be made from data on conspecifics.

In this study I examined allozymes in blood of tule elk taken from 2 populations, and allozymes in liver and kidney from one of the same populations. My objectives were: (1) to determine if electrophoretically detectable genetic variation exists in these animals, (2) to compare genetic variation in tule elk to that in other elk subspecies, and (3) to suggest management strategies to maintain variation that may be present.

METHODS

The populations used in this study were from the Tupman Reserve (TR), Kern County, and the Owens Valley (OV). The TR is a 386 ha enclosure established in 1932 to contain the elk population near Buttonwillow; there initially were 140 animals in the reserve (McCullough 1969). Subsequent population size was maintained generally below 100, and as low as 28, by culling and transplants (CDFG 1985, 1989). The OV population, not in historic tule elk range, was founded in 1933-34 with 54 animals transplanted from the Buttonwillow herd and from Yosemite National Park, which in turn came from the Buttonwillow herd (McCullough 1969). The OV population grew to 189 in 1943 and to more than 600 in 1984.

Blood samples from 40 live tule elk were taken during capture operations at OV in November 1985 and from 36 tule elk at TR in October 1989. In addition, liver samples from 24 hunter-killed tule elk and kidney samples from 13 of the same individuals were taken during November 1989 at OV. Blood was collected in vacuum tubes containing the anticoagulant EDTA, placed on ice, and centrifuged within several hours. Serum and red cells were decanted into cryogenic vials. The OV blood samples were placed in liquid nitrogen for several days, and then stored in a freezer at -60°C until shipped on dry ice to the electrophoretics laboratory in December 1988. The TR serum and red cell samples were placed on dry ice immediately after being decanted into cryogenic vials and shipped on dry ice to the laboratory the day of collection. The liver and kidney samples were placed in cryogenic vials on dry ice within a few hours of death of the animal and shipped on dry ice to the electrophoretics laboratory within 3 days.

In the laboratory, samples were analyzed by horizontal starch-gel electrophoresis as outlined by May et al. (1979). Liver and kidney samples from individuals were combined for analysis.

RESULTS

Of the 38 loci that were scored, 2 were polymorphic: adenylate kinase (AK) and mannosphosphate isomerase (MPI; Table 1). AK had 3 alleles, MPI had 2. Both variable enzymes were in liver and kidney from OV elk; all enzymes examined in blood were invariant. That MPI appeared monomorphic in blood could have resulted from the difficulty of scoring it from blood (B. May, pers. comm.). The proportion of polymorphic loci (P) was 0.053. The frequency of the two most common alleles of AK were 0.674 and 0.304; the frequency of the common allele of MPI was 0.707. The observed genotype frequencies of AK differed significantly from Hardy-Weinberg proportions ($G = 7.58$, $df = 1$, $P < 0.01$), with an apparent excess of heterozygotes. Genotype frequencies of MPI did not differ from Hardy-Weinberg proportions ($G = 0.802$, $df = 1$, $P > 0.1$).

Table 1. Enzymes analyzed electrophoretically from blood, liver and kidney taken from tule elk in the Owens Valley (OV, *n* = 40 blood, 24 liver and 13 kidney), Inyo County, and on the Tupman Reserve (TR, *n* = 36), Kern County, California. "M" indicates those from monomorphic loci; "V" indicates a variable locus; a blank indicates that the enzyme was not scored.

Locus	Blood		Liver and Kidney
	OV	TR	OV
Adenylate kinase (AK)			V
Aspartate aminotransferase (AAT)	M		M
Creatine kinase (CK)			M
Diaphorase (DIA)	M	M	
Esterase-1 (EST-1)	M	M	
Esterase-2 (EST-2)	M	M	
Fumarase (FUM)			M
Galactosaminadase (GAM)	M	M	M
Glucose-6-phosphate dehydrogenase (G6PDH)			M
beta-Glucosidase (beta-GLU)			M
Glucosephosphate isomerase (GPI)	M	M	
Glutamic pyruvic transaminase (GPT)			M
Glyceraldehyde-3-phosphate dehydrogenase (GAPDH)			M
Isocitrate dehydrogenase (IDH)	M	M	M
Lactate dehydrogenase-1 (LDH-1)	M	M	M
Lactate dehydrogenase-2 (LDH-2)	M	M	M
Malate dehydrogenase-1 (MDH-1)	M	M	M
Malate dehydrogenase-2 (MDH-2)			M
Malic enzyme (ME)		M	
alpha-Mannosidase (alpha-MAN)	M	M	M
Mannosephosphate isomerase (MPI)	M	M	V
Methylumbelliferyl phosphatase-1 (MUP-1)	M	M	
Methylumbelliferyl phosphatase-2 (MUP-2)	M	M	
Peptidase with leucyl-alanine (PEP-LA)		M	M
Peptidase with leucyl-glycyl-glycine-1 (PEP-LGG-1)		M	M
Peptidase with leucyl-glycyl-glycine-2 (PEP-LGG-2)			M
Peptidase with phenyl-alanyl-proline (PEP-PAP)			M
Phosphoglucomutase (PGM)	M		M
Phosphogluconate dehydrogenase (PGD)	M	M	M
Phosphoglycerate kinase (PGK)			M
General protein-1 (PRO-1)	M	M	
General protein-2 (PRO-2)	M	M	M
General protein-3 (PRO-3)			M
Inorganic pyrophosphatase-1 (PP-1)			M
Inorganic pyrophosphatase-2 (PP-2)			M
Sorbitol dehydrogenase (SDH)			M
Superoxide dismutase (SOD)	M	M	M
Triosphosphate isomerase (TPI)		M	M

DISCUSSION

The interpretation of the apparent level of genetic variation in tule elk from this examination depends on the amount present before their 19th Century bottleneck. If they had little genetic variation before the bottleneck, and thus had little to lose, concerns about deleterious effects of inbreeding and loss of ability to adapt to new selection pressures would be less urgent. The original genetic variation in tule elk is unknowable, but may be approximated by that in other elk subspecies that have not experienced such drastic declines. Such a comparison must be done with caution, however, because the population histories of the other animals analyzed are not well known.

All North American elk subspecies are believed to have derived from ancestral stock that crossed the Bering land bridge during the Illinoian glacial stage some 120,000 years ago and expanded throughout much of the continent (Guthrie 1966). Elk in North America spread southward and eastward from Alaska during the Sangamonian interglacial stage, and then were isolated into four geographical segments during the Wisconsin glaciation, from about 70,000 to 10,000 years ago (Guthrie 1966, McCullough 1969, Bryant and Maser 1982). Both tule and Roosevelt, *C. e. roosevelti*, elk may have originated from a westward expansion of Rocky Mountain, *C. e. nelsoni*, elk through southern Oregon and northern California (McCullough 1969). Sage and Wolff (1986) suggested that Dall sheep, *Ovis dalli*, and other animals of glaciated areas exhibit lower genetic diversity because of founder effects resulting from "serial recolonization" after repeated episodes of glaciation. They also speculated that in a species expanding its range, the youngest populations, or those at the edge of the range, would suffer the greatest loss of alleles. Thus, according to the Sage and Wolff (1986) "stepping-stone" model of range establishment, tule and Roosevelt elk may be expected to have less genetic diversity than the "older" subspecies from which they derived. However, there probably was some contact with Roosevelt and Rocky Mountain elk, at least within the last several thousand years, which served to decease the isolation of the tule elk (D. McCullough, pers. comm.).

Cameron and Vyse (1978) found that Rocky Mountain elk from Yellowstone National Park were polymorphic at 1 (IDH) of 24 loci ($P = 0.042$) they examined. Baccus et al. (1983) reported that Rocky Mountain elk from Montana, near Yellowstone, were polymorphic at 2 (IDH and MPI) of 19 loci ($P = 0.105$). Dratch and Gyllensten (1985) examined enzyme polymorphisms in Rocky Mountain and Roosevelt elk from 11 locations in the northwestern United States. They found from 2 to 5 (IDH, MPI, PEP, PGM, and SOD) of 28 loci ($0.071 < P < 0.178$) variable in any population. The most variable elk were Roosevelt elk. They also remarked that the Yellowstone National Park elk studied by Cameron and Vyse (1978) were particularly low in allozyme variability. Because of glaciation, elk could not have occupied most of the Yellowstone area until about 12,000 years ago (Houston 1982), and their apparently low genetic variability is consistent with the Sage and Wolff (1986) model.

These other studies of genetic variability in elk analyzed liver, kidney, heart and muscle tissues; Cameron and Vyse (1978) also reported using blood. With the exception of MPI, all of the enzymes identified as polymorphic in Rocky Mountain and Roosevelt elk were monomorphic in tule elk (Table 1); however, AK was not examined in these other studies. IDH, polymorphic in 10 of the 11 populations studied by Dratch and Gyllensten (1985), was monomorphic in tule elk from OV. Thus, all populations of the 2 subspecies studied by Dratch and Gyllensten (1985) showed genetic diversity greater than that found in tule elk; these other subspecies also had several variable enzymes that were invariant in tule elk. The relatively lower genetic variation in tule elk is probably not just a result of their colonization history. Both Roosevelt and tule elk, derived from the same parent stock, could be expected to have comparable genetic variability. Tule elk, however, having experienced a severe bottleneck, likely lost alleles as a consequence of that bottleneck.

MANAGEMENT

Tule elk exist in many disjunct populations, most of them small, with different histories (CDFG 1985). Thus, with the possible exception of the OV population, tule elk remain in a severe bottleneck. The present study demonstrates that there is some genetic variation in the largest population, that from OV. No variation was apparent in TR elk, but only blood was analyzed. That some genetic variation does exist in TR elk is apparent from the existence of an apparently congenital facial abnormality resulting in malocclusion of the incisors with the dental pad (CDFG 1985). When this condition first was noticed in the 1950's, the affected animals were removed from the herd. However, the condition reappeared in the 1970's. The cause is likely genetic, possibly a recessive allele expressed in the homozygous genotype as a result of inbreeding. Although this is a condition that would rapidly be selected against in a natural situation, the TR diet of pelleted alfalfa allows affected individuals to survive and reproduce. Since the condition was known, several transplants from TR have been made. As discussed in CDFG (1985:86), this is unwise, and should be discontinued. When the TR population grows to a size too large for the enclosure, excess animals should be translocated only after sterilization, or sacrificed.

Patterns of genetic variation in the other tule elk populations are unknown. Any strategy to maintain existing alleles and to minimize inbreeding necessarily involves moving animals among populations, and such a strategy must be developed from a knowledge of existing conditions within the populations. McClenaghan et al. (1990) discussed the existence of varying levels of genetic differentiation among small, disjunct populations of plains bison, *Bison bison*, another large mammal that experienced a bottleneck. However, in tule elk, the analysis of the existing disjunct populations and comparisons among them are complicated by the fact that the polymorphic enzymes in the current study were identified only from tissues that required the death of the animal. Analyses using blood alone would have resulted in the conclusion that tule elk were monomorphic. Analysis of other tissues obtained from live animals, e.g., ear punctures, should be attempted. Other techniques of

assessing genetic variability, such as blood-group typing and mitochondrial DNA analyses, also could be performed. Although Cronin (1989) found little variation in mitochondrial DNA from elk, blood-group typing has shown variability among OV animals (Kucera, unpubl. data), and could be a valuable technique especially because it does not require the death of the animal. In capture operations in the future, blood for this type of analysis could be readily available.

The tule elk hunting program, involving several populations in addition to the OV, provides an opportunity to advance knowledge of elk genetics to guide management. Striated muscle as well as liver and kidney should be taken for analysis from all hunter-killed animals. Mandatory reporting by hunters to a check station allows this to be readily done. The Cache Creek herd in Colusa County, one of the hunted populations, is of particular interest, having been founded in 1922.

Until genetic data are more complete, management of demography, i.e., population size, must be stressed. There is no doubt that if given high quality habitat, tule elk can increase rapidly (Gogan and Barrett 1987). At present, the best way to manage tule elk to maintain existing genetic variation is to maximize population size (Lande 1988). However, the constraints to further tule elk population growth presented by the limited additional habitat available within historic range, discussed in CDFG (1989), the isolated nature of most of the extant populations, and the expense of translocations make a large growth in tule elk numbers and gene flow among populations unlikely. These demographic constraints underscore the need for more extensive information on tule elk genetics to guide long-term conservation and management. At the least, gene flow can be maintained by translocating animals. Genetic data can guide this gene flow from more to less genetically variable populations.

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GRAY WOLVES IN CALIFORNIA: THEIR PRESENCE AND ABSENCE

ROBERT H. SCHMIDT
Department of Forestry and Resource Management
University of California
Berkeley, CA 94720[1]

Gray wolves, *Canis lupus*, probably occurred in the Central Valley, the western slope of the Sierra Nevada foothills and mountains, and in the Coast Ranges of California until the early 1800s, although their population size is unknown and may have been small. Fossil records and early recorded observations attest to the presence of gray wolves in these areas. In addition, the proximity of other wolf populations east of the Sierra Nevada and north of California, the extensive historical range of gray wolves world-wide, and the presence of large ungulates as potential prey provide indirect evidence that wolves inhabited this region. If gray wolves were more abundant and widely distributed 300 years ago, it is possible that there were fewer coyotes, *C. latrans*, than at present. Community-level dynamics between canids (including the San Joaquin kit fox, *Vulpes macrotis*) may have been much different than they are today.

There is some question about the abundance and distribution of gray wolves in the recent past in California. Hall (1981:932) and Mech (1970:31) considered most of North America as historical range of gray wolves, excluding only the southeastern part of the United States and most of California. Paradiso and Nowak (1982:461) concurred, stating "There are no precise records for most of the state of California; the wolf may have been there, but was eliminated at an early time... ." Grinnell (1936:114) speculated that wolves "... occurred far and wide through northern and eastern portions of [California]; no available evidence indicates presence within historic times in west-central California or in southern California west of deserts." Ingles (1965:342) stated "It seems likely that a few wolves remain in the high central Sierra Nevada... ."

Gray wolves, *C. l. furlongi*, were native to California prior to human colonization (Nowak 1979). Fossils have been discovered in Shasta, Kern, Los Angeles, and San Bernardino Counties. Specimens collected from Rancho La Brea in Los Angeles County date 10,000 + years before present (C. A. Shaw, George C. Page Museum, pers. comm.).

There are at least two important reasons for discovering the recent distribution of gray wolves in California. Periodically, there is discussion about the reintroduction of wolves into the state. The expansion of gray wolves into northern Washington in

[1]Present address: Department of Fisheries and Wildlife, Utah State University, Logan, UT 84322-5210

1990 (Anon. 1990) may increase interest in this controversy. Whether or not this is ever acceptable or practical, a first step would be to determine if wolves ever occurred at a particular location. Second, if wolves were present in historic times and were relatively or locally abundant, they may have had significant impacts on community structure of ecosystems where they occurred. The absence of wolves may assist in explaining patterns of abundance and distribution in species present today.

METHODS

I searched through the writings of early explorers, naturalists, and others that may have come across gray wolves in California. Although my search was not exhaustive, I did go through >50 accounts of life in early California (Schmidt 1987). Sightings of gray wolves were assumed valid when either the writer was a trained naturalist or when the writer specifically distinguished between gray wolves, coyotes, and foxes. The latter rule was deemed important because coyotes in the mountains attained a larger size than lowland coyotes and often were mistaken as "wolves." As an example, explorer F. W. Beechey (1941:65) wrote of his travels from 1826-1827 in the Monterey Bay area that "... wolves and foxes are numerous, and the *cuiotas*, or jackals, range about the plains at night... ." I considered this a probable sighting of gray wolves.

RESULTS

1750 -1850 Records

Clear records exist from the middle 1750s to the middle 1850s. Pedro Fages (Priestly 1937) explored the Coastal Range from San Diego to San Francisco in 1769 and made numerous references to wolves, coyotes, and foxes. For example, in 1769 while traveling through the San Diego area, Fages noted that "In this territory there are to be seen, besides a number of other land animals, deer, antelope, conies, hares without number, wildcats, wolves, some bears, coyotes, and squirrels of three kinds" (Priestley 1937:12). Russian explorer Von Kotzebue (1830) described two species of "wolves" as he explored the San Francisco Bay into the Sacramento-San Joaquin Valley. From his descriptions, these were most likely gray wolves and coyotes. Additional sightings by other early explorers were made in the Monterey Bay area (1826), near the San Gabriel Mission in southern California (1827), and in Humboldt County (1828) (Schmidt 1987). The pattern of these sightings (Fig. 1) is indicative of the pattern of settlement in California, with sightings predominant in the coastal areas being settled.

1851 -1900 Records

From 1851 through 1900, the distribution of sightings changed significantly. Wolves were reported in northern Shasta County and in the central Sierra Nevada

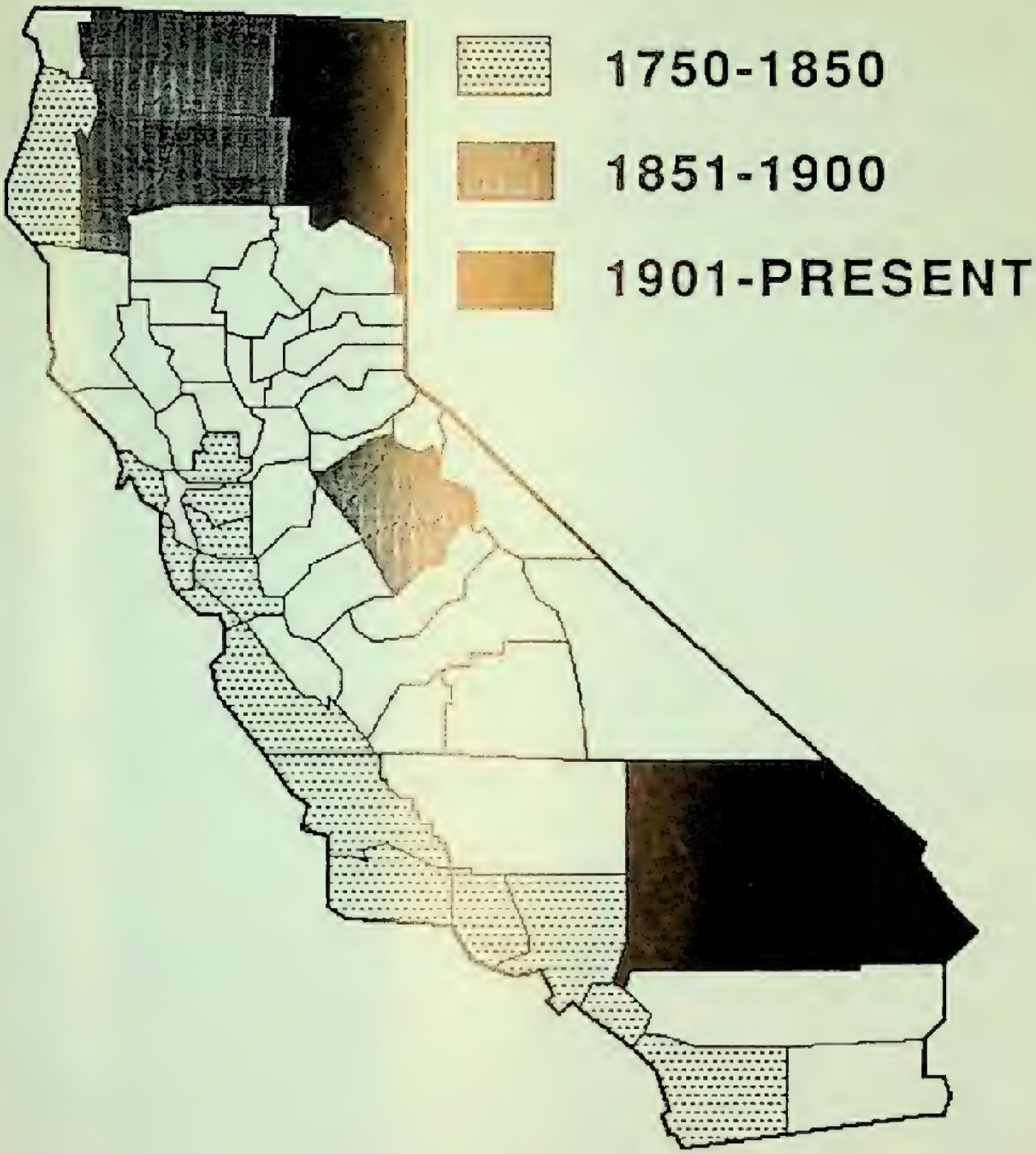

Figure 1. California counties where records indicated the presence of gray wolves in the periods 1750-1850, 1851-1900, and 1901-present.

Table 1. Specimens of gray wolves, *Canis lupus*, from California at the Museum of Vertebrate Zoology, University of California, Berkeley.

Identification: *Canis lupus youngi* MVZ No.: 33389 Sex: male
Collection Date: ca. 14 December 1922 Collector: Mr. Watson and A. B. Montgomery
Collection locality: San Bernardino County, Old Barnett Mine, 12 miles west of Lanfair in the Providence Mts.
Comments: skull only.

Identification: *Canis lupus fuscus* MVZ No.: 34228 Sex: male
Collection Date: 12 June 1924 Collector: F. Kaehler
Collection locality: Lassen County, near Litchfield
Comments: skull missing, leg bones available.

Identification: *Canis lupus* MVZ No.: 129254 Sex: male
Collection Date: 22 March 1962 Collector: David Boas
Collection locality: Tulare County, 1 mile east of Woodlake
Comments: complete skeleton available; identified by McCullough (1967) as an introduced Asiatic wolf, possibly *C. l. chanco*.

(Fig. 1). These observations included wolves sighted by naturalists accompanying railway survey crews and reports by explorer/trappers (Schmidt 1987). Newberry (1857:37) reported that "Though much less common than the coyote', the large grey wolf is found in all the uninhabited parts of California and Oregon. ... All the large wolves seen by any of our party were grey, and all the skins which I saw in the possession of Indians or whites were also grey, and it is probable that the white and black varieties are never found in California." Price (1894) noted the observations of a trapper named Dent who reported seeing gray wolves in the central Sierra Nevada above 6,000 feet in elevation.

1901 - Present Records

During this period, naturalists began requiring more than visual sighting records for confirmation of the presence of species (Fig. 1). The only museum specimens of recent wolves in California were collected during this period (Table 1). A wolf, *C. l. youngi*, was trapped in the Providence Mountains (San Bernardino County) in 1922, and another specimen, *C. l. fuscus*, was trapped in Lassen County in 1924 (Grinnell et al. 1937:527). Grinnell et al. (1937:530) were convinced of additional sightings in Modoc County. Young (1964:55) reprinted U. S. Forest Service estimates of gray wolf numbers in six National Forests for 1939. These estimates were: Lassen (16), Tahoe (4), Eldorado (12), Stanislaus (6), Angeles (5), and Rogue River (5). However, he concluded that it was questionable whether any wolves still survived in California.

DISCUSSION

When these sightings are combined, it appears that gray wolves originally occurred throughout California. For this survey, a single sighting of a wolf in a diary has the same weight as a sighting of a large pack of wolves. Thus, the distribution picture is rather coarse-grained. It is significant that as the settlement of California progressed inward from the coast, sightings ceased from the settlement and livestock production areas and were reported only in more remote locations.

Gray wolves probably occurred in the Central Valley, Coast Ranges, and the Sierra Nevada until the early 1800s. Elk, pronghorn, and deer (*Cervus*, *Antilocapra*, and *Odocoileus* spp.) were abundant in early California (McCullough 1969), providing a potential prey base for wolves. Grizzly bears, *Ursus arctos*, also were abundant (Hicks 1983), and may have competed with wolves for available prey.

Historical gray wolf densities are unknown. I suspect the early livestock industry, using guns, traps, and poisons, was very effective in eliminating both the grizzly and the wolf. There is evidence that intensive predator control was responsible for the temporary extirpation of coyotes, a much more resilient species, from selected areas in the western United States in the early 1900s (Schmidt 1986). Gray wolves, *Canis lupus*, probably were extirpated in California in the mid-1920s (Williams 1979). The few wolves collected since then apparently have been released captive animals (for example, McCullough 1967, Anon. 1989).

The impact of the extirpation of the wolf on the community structure of California's wildlife can be speculative at best. However, there are indications that the impact may not have been minor. Elsewhere I have indicated (Schmidt 1986) that strong interspecific interactions occur between canids occupying similar habitat. These interactions are strong enough that the addition or removal of one canid species often has been recommended as a management technique to impact another canid species (Schmidt 1985, 1986). For example, coyote introductions have been proposed to reduce populations of red foxes, *Vulpes vulpes*, in areas where foxes are having an impact on endangered bird populations. It is reasonable to assume that, if wolves were present historically in California, their removal allowed coyotes to move into new areas or to reach higher population densities. This may explain the high mortality rate (up to 50% of marked animals) of San Joaquin kit fox, *Vulpes macrotis mutica*, caused by predators, chiefly coyotes (O'Farrell 1984; also noted for *V. m. arsipus* by O'Farrell and Gilbertson 1986). Thus, O'Farrell's (1984:208) statement that coyote predation on kit foxes "... appears to be a natural risk" may not be the case. Such interactions obviously are complicated by the extirpation of the grizzly, the alteration of California's flora (especially the introduction of alien annual grasses), the interruption of historical wildfire cycles, and past and present human impacts. Predator-prey dynamics, competitive interactions, and other community-level phenomena 200 years ago certainly would have been different with gray wolves as part of the biota.

Additional research would be useful in refining the known distribution of gray wolves in California. This research could include additional reviews of historical

literature and early mission records, analysis of Native American artifacts (including dating when possible), and additional paleontological searches. With this information, the role, impact, and place of gray wolves in California's landscape can continue to be evaluated.

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COMPUTERIZED DATA BASE FOR EXOTIC FISHES: THE WESTERN UNITED STATES

James D. Williams and Dawn P. Jennings[1]
U. S. Fish and Wildlife Service
National Fisheries Research Center
Gainesville, Florida 32606

Since 1978, the National Fisheries Research Center-Gainesville, Florida, has been monitoring the status, distribution, and potential impacts of exotic fish species in open waters of the United States. Exotic species are those not indigenous to the United States (Shafland and Lewis 1984). To date, at least 126 species of exotic fishes have been taken from open waters in the continental United States, and 46 of them represent established populations (Courtenay et al. 1991). In the western states, 80 species are established and 68 have been collected but are not known to be established. Most collected species represent releases of aquarium fishes or escapes from aquaculture facilities. Others represent purposeful introductions by government agencies for biological control or for sport fishing.

To facilitate information transfer about exotic species, we are computerizing all records for exotics from open waters throughout the United States. Information on each introduction is obtained by contacting state and federal agencies, fisheries biologists, and museum curators and by researching laboratory and museum collections, published literature, and unpublished reports. These data are then compiled and arranged into the database format. We have entered about 600 records for specific introductions and anticipate entering at least 1,000 records in 1990-1991.

The data base was created with dBASE III Plus software. Each record for a particular exotic fish collection includes information on taxonomy, locality, methods of collection, disposal of specimens, and the status of the introduction (Fig. 1). Definitions for specific fields used for each record are given in Table 1.

There is obviously a need for synthesis and organization of exotic fish records. Present information on distribution is scattered and not very accessible. As a result, some records in natural history museums have never been reported, and others have been overlooked in files and unpublished reports. Geographical areas of primary concern in the U.S. include the state of Florida and the southwestern U.S. (Arizona, southern California, and Nevada). Because of the subtropical climate, these areas support a greater number and diversity of exotic species than northern locations. Monitoring of established exotics in the western U.S. is extremely important because of potential adverse effects on indigenous threatened and endangered species. Declines in distribution and abundance and even local extirpation of native species have been attributed to the introduction of exotic organisms (Taylor et al. 1984).

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[1]Current address is U.S. Fish and Wildlife Service, Office of Information Transfer, Fort Collins, CO 80524

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DATE-ENT >      < GROUP (        ) FAMILY (                )
GENUS (                  ) SP (                            )
SUBSP (                  ) COM_NM (                        )
ID_BY (

CNTRY (     ) ST (   ) CO (         ) DR (                 )
Y ( ) M ( ) D ( ) QD_MAP (         ) TRS (                 )
UTM_COORD (                ) LAT (       ) LONG (         )
LOCALITY (                                                 >

COLLECTOR (                                                )
METHOD (                 ) NO_COLL (     ) YR_CLS (        )
DISPOSAL (               ) MUS_NO (                        )
TYPE_INTRO (             ) STATUS (                        )
AGENCY (                 ) STK_SOURCE (                    )
BIBLIO (                                                   >

HABITAT (                                                  >

COMMENTS (                                                 >
```

Figure 1. Example of database record.

The data base was created as a mechanism for obtaining and disseminating pertinent information on exotic introductions and will serve as a centralized source of data for exotic fishes in the United States. It will provide a complete listing of collections and personal observations of exotics on a national basis. It ultimately will be an information exchange base for monitoring distribution, rate of dispersal, and potential range expansion of established populations. The data base is presently available to individuals and state and federal agencies to enhance awareness of exotic species introductions and facilitate management decisions concerning exotics. Most entered records to date are from the southeastern U.S., primarily Florida; however, about 150 records exist from the western U.S.

We are encouraging state agencies to contact us with information on any exotic fish collections for the data base. A list summarizing the species collected or established in western states is provided in Table 2. Please contact the authors for additions, deletions, or other changes to this list.

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Table 1. Definitions for database fields.

DATE_ENT	Date record was entered on the database.
GROUP	Name of group of animals (clams, fishes, snails, birds, etc.) to which the species belongs.
FAMILY	Family.
GENUS	Genus.
SPECIES	Species.
SUBSP	Subspecies name, if one is available.
COM_NM	Common name(s) for the species in popular or scientific literature.
ID_BY	Name, address and phone number of person identifying the specimen.
CNTRY	Country where the specimen was collected.
ST	State where specimen was collected.
CO	County where specimen was collected.
DR	Drainage basin of the water body where specimen was collected.
Y	Year collection was made.
M	Month collection was made.
D	Day collection was made.
QD_MAP	Name of USGS quadrangle map.
TRS	Township, Range and Section.
UTM_COORD	Universal Transverse Mercator Coordinates.
LAT	Latitude.
LONG	Longitude.
LOCALITY	Verbal description of the locality.
COLLECTOR	Name, address and phone number of person making the collection.
METHOD	Method used in making collection.
NO_COLL	Number of individuals collected.
YR_CL	Year class or size range of specimen collected.
DISPOSAL	How the specimens were disposed of: discarded, frozen, preserved, etc.
MUS_NO	Museum name and number if deposited in a collection.
TYPE_INTRO	Type of introduction: aquarium, aquaculture, bait fish, sport fish, etc.,or unknown.
STATUS	Established, possibly established, localized, or unknown.
AGENCY	Agency or individual (if known) responsible for stocking.
STK_SOURCE	Source of the stock of the introduction.
BIBLIO	Primary reference if the record is from the literature.
HABITAT	Habitat where the species was taken.
COMMENTS	Miscellaneous comments pertaining to the record.

Table 2. Exotic fishes established and collected by state.

ALASKA

Established (None)

Collected (None)

ARIZONA

Established (8)

Carassius auratus	goldfish
Cyprinus carpio	common carp
Poecilia mexicana	shortfin molly
Poecilia reticulata	guppy
Salmo trutta	brown trout
Tilapia aurea	blue tilapia
Tilapia mossambica	Mozambique tilapia
Tilapia zilli	redbelly tilapia

Collected (10)

Astyanax mixicanus	Mexican tetra
Cichlasoma meeki	firemouth cichlid
Cichlasoma nigrofasciatum	convict cichlid
Colossoma sp.	pacu
Ctenopharyngodon idella	grass carp
Hypophthalmichthys molitrix	silver carp
Hypophthalmichthys nobilis	bighead carp
Tinca tinca	tench
Xiphophorus helleri	green swordtail
Xiphophorus variatus	variable platyfish

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Established (18)

Acanthogobius flavimanus	yellowfin goby
Anisotremus davidsoni	sargo
Bairdiella icistia	bairdiella
Carassius auratus	goldfish
Cynoscion xanthulus	orangemouth corvina
Cyprinus carpio	common carp
Hypomesus nipponensis	wakasagi
Misgurnus anguillicaudatus	oriental weatherfish
Poecilia mexicana	shortfin molly
Poeciliopsis gracilis	porthole livebearer
Rivulus harti	giant rivulus
Salmo trutta	brown trout
Tilapia aurea	blue tilapia
Tilapia mossambica	Mozambique tilapia
Tilapia urolepis hornorum	wami tilapia
Tilapia zilli	redbelly tilapia
Tinca tinca	tench
Tridentiger trigonocephalus	chameleon goby

Table 2. cont.

Collected (19)	
Anguilla anguilla	European eel
Anguilla australis	shortfinned eel
Barbus tetrazona	tiger barb
Chanos chanos	milkfish
Cichlasoma beani	green guapote
Cichlasoma octofasciatum	Jack Dempsey
Clarias batrachus	walking catfish
Colossoma sp.	pacu
Ctenopharyngodon idella	grass carp
Cynolebias bellottii	Argentine pearlfish
Cynolebias nigripinnis	blackfin pearlfish
Cynolebias whitei	pearlfish
Danio rerio	zebra danio
Oryzias latipes	medaka
Osteoglossum bicirrhosum	arowana
Plecoglossus altivelis	ayu
Poecilia reticulata	guppy
Xiphophorus helleri	green swordtail
Xiphophorus maculatus	southern platyfish
Xiphophorus variatus	variable platyfish
COLORADO	
Established (4)	
Carassius auratus	goldfish
Cyprinus carpio	common carp
Salmo trutta	brown trout
Tinca tinca	tench
Collected (3)	
Ctenopharyngodon idella	grass carp
Tilapia aurea	blue tilapia
Tilapia mossambica	Mozambique tilapia
IDAHO	
Established (10)	
Carassius auratus	goldfish
Cichlasoma nigrofasciatum	convict cichlid
Cyprinus carpio	common carp
Misgurnus anguillicaudatus	oriental weatherfish
Poecilia mexicana	shortfin molly
Poecilia reticulata	guppy
Salmo trutta	brown trout
Tilapia mossambica	Mozambique tilapia
Tinca tinca	tench
Xiphophorus helleri	green swordtail

Table 2. cont.

Collected (3)	
Ctenopharyngodon idella	grass carp
Tilapia aurea	blue tilapia
Tilapia mossambica	Mozambique tilapia
MONTANA	
Established (6)	
Carassius auratus	goldfish
Cyprinus carpio	common carp
Poecilia mexicana	shortfin molly
Salmo trutta	brown trout
Xiphophorus helleri	green swordtail
Xiphophorus variatus	variable platyfish
Collected (2)	
Salmo letnica	Ohrid trout
Tilapia mossambica	Mozambique tilapia
NEVADA	
Established (10)	
Carassius auratus	goldfish
Cichlasoma nigrofasciatum	convict cichlid
Cyprinus carpio	common carp
Hypostomus sp.	armored catfish
Poecilia mexicana	shortfin molly
Poecilia reticulata	guppy
Salmo trutta	brown trout
Tilapia mariae	spotted tilapia
Xiphophorus helleri	green swordtail
Xiphophorus maculatus	southern platyfish
Collected (13)	
Ameca splendens	butterfly splitfin
Cichlasoma severem	banded cichlid
Cichlasoma trimaculatum	threespot cichlid
Clarias batrachus	walking catfish
Ctenopharyngodon idella	grass carp
Melanochromis auratus	gold mbuna
Melanochromis johanni	blue mbuna
Osteoglossum bicirrhosum	arowana
Poecilia sp. hybrids	
Pseudotropheus zebra	zebra mbuna
Tilapia mossambica	Mozambique tilapia
Tilapia zilli	redbelly tilapia
Tinca tinca	tench

Table 2. cont.

NEW MEXICO	
Established (3)	
Carassuis auratus	goldfish
Cyprinus carpio	common carp
Salmo trutta	brown trout
Collected (6)	
Bairdiella icistia	bairdiella
Ctenopharyngodon idella	grass carp
Cynoscion xanthulus	orangemouth corvina
Danio rerio	zebra danio
Tinca tinca	tench
Poecilia reticulata	guppy
OREGON	
Established (3)	
Carassius auratus	goldfish
Cyprinus carpio	common carp
Salmo trutta	brown trout
Collected (1)	
Tinca tinca	tench
TEXAS	
Established (10)	
Carassius auratus	goldfish
Ctenopharyngodon idella	grass carp
Cyprinus carpio	common carp
Hypostomus sp.	armored catfish
Poecilia mexicana	shortfin molly
Poecilia reticulata	guppy
Salmo trutta	brown trout
Tilapia aurea	blue tilapia
Tilapia mozzambica	Mozambique tilapia
Tilapia zilli	redbelly tilapia
Collected (10)	
Astronotus oscellatus	oscar
Belonesox belizanus	pike killifish
Chirostoma jordani	charal
Cichla ocellaris	peacock cichlid
Cichla temensis	speckled pavon
Colossoma sp.	pacu

Table 2. cont.

Cynoscion xanthulus	orangemouth corvina
Lates mariae	bigeye lates
Lates niloticus	nile perch
Scardinius erythrophthalmus	rudd
UTAH	
Established (3)	
Cyprinus carpio	common carp
Poecilia reticulata	guppy
Salmo trutta	brown trout
Collected (1)	
Ctenopharyngodon idella	grass carp
WASHINGTON	
Established (4)	
Carassius auratus	goldfish
Cyprinus carpio	common carp
Salmo trutta	brown trout
Tinca tinca	tench
Collected (3)	
Colossoma sp.	pacu
Ctenopharyngodon idella	grass carp (triploid)
Serrasalmus sp.	piranha
WYOMING	
Established (4)	
Cyprinus carpio	common carp
Poecilia reticulata	guppy
Salmo trutta	brown trout
Xiphophorus helleri	green swordtail
Collected (3)	
Ctenopharyngodon idella	grass carp
Salmo letnica	Ohrid trout
Puntius tetrazona	tiger barbs

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MACROINVERTEBRATE COLONIZATION OF HESTER-DENDY SAMPLERS IN DIFFERENT ORIENTATIONS TO WATER FLOW

JEFFREY P. HILL[1] AND WILLIAM J. MATTER
School of Renewable Natural Resources
University of Arizona
Tucson, Arizona 85721

Hester-Dendy (multiple-plate) invertebrate samplers have been widely used in ecological monitoring studies (Fullner 1971, Mason et al. 1973, Cover and Harrel 1978). Hester-Dendy samplers, first designed by Hester and Dendy (1962), have been modified by increasing the number of plates per sampler from eight to 14 and varying the distance between plates (Fullner 1971). Parsons and Tatum (1974) suggested that sampler plates should be round rather than square, so that colonized samplers could be stored in plastic bags of preservative. Weber (1973) recommended that round plates of 2.5-cm and 7.5-cm diameter be alternated on the sampler. Harrold (1978) recommended alternating the orientation of the smooth and rough sides of plates on samplers to increase invertebrate colonization.

Although much work has been done to improve the design of Hester-Dendy samplers and to compare them to other sampling methods (Fullner 1971, Mason et al. 1973, Fredeen and Spurr 1978, Tsui and Breedlove 1978), no work has been done on how colonization of samplers is affected by their orientation to water flow. Hester-Dendy samplers are usually oriented with the plates parallel to the direction of water flow (Fullner 1971, Cover and Harrel 1978), but no standard orientation has been proposed (American Public Health Association 1980). The orientation of samplers to water flow must affect water velocities over the plate surfaces. Water velocity is known to be an important factor influencing the distribution and abundance of aquatic invertebrates (Merritt and Cummins 1984). Beckett and Miller (1982) compared the colonization of Hester-Dendy samplers set with the plates parallel to the flow in areas of slow and fast current. They reported that the water velocity over the sampler had a significant affect on invertebrate colonization. Our study was conducted to test whether the orientation of benthic Hester-Dendy samplers to water flow affected macroinvertebrate colonization.

Macroinvertebrates were sampled in Dana Creek, a tributary of the Tuolumne River, in the eastern area of Yosemite National Park, California. Samplers were placed in Dana Creek (Sec. 6, T1S, R1E) at an elevation of 2,877 m in a riffle area with a surface velocity that ranged from 0.15-0.30 m/s and averaged 0.26 m/s. At the study site, the creek was 8.5 m wide and ranged in depth from 10-24 cm. The stream substrate was predominantly 2-5 cm gravels.

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[1] Current Address: Dept. of Biological Sciences, Idaho State University, Pocatello, ID 83209

We used Hester-Dendy samplers with 8, 76.2-mm square plates, 3.2 mm thick, separated by spacers (25.4 mm square and 6.4 mm thick) and held together with an eye bolt. Samplers were assembled with the rough side of all plates oriented away from the eye end of the eye bolt.

A nylon cord for anchoring samplers was secured with stakes to the stream bottom, perpendicular to the direction of water flow. Samplers to be held parallel to the direction of water flow were connected to the nylon cord by two 16 cm sections of wire, one on each end of the eye bolt through the sampler. Samplers in the parallel orientation were mounted so that one edge of each sampler plate was in contact with the substrate. Samplers to be held perpendicular to the direction of water flow were connected to the nylon cord by one 16 cm length of wire from the eye end of the sampler bolt. Thirty samplers were installed across the stream riffle, at least 16 cm apart, during each of two 28 day colonization periods (28 June 1981-26 July 1981 and 26 July 1981-23 August 1981). The orientation of adjacent samplers was alternated. The Environmental Protection Agency recommends a 6-week colonization period (Weber 1973), but Tsui and Breedlove (1978) indicated that the diversity and number of insects on samplers declines after 30 days.

Samplers were collected after colonization by gently lifting each sampler off the substrate and enclosing it in a plastic bag. Once a sampler was sealed in a bag, the anchoring wires were cut. The sampler and the contents of the bag were placed into a sorting tray. Samplers were disassembled and all obvious invertebrates were removed. The surfaces of all sampler parts were then gently scrubbed with a plastic bristle scrub brush in the sorting tray. All invertebrates were filtered from the water in the sorting tray and preserved in 70% ethyl alcohol. Insects were keyed to family using Lehmkuhl (1979).

Data were analyzed using a chi-squared goodness of fit analysis (Zar 1984). For a given orientation, invertebrate colonization of samplers (numbers of genera) was not significantly different between the two sampling periods (X^2, $P > 0.25$). Data from the two sampling periods was combined prior to analysis of the effect of orientation.

For nine of the 12 insect families collected, no difference in abundance on samplers was observed with respect to orientation (Table 1). More Ephemerellidae colonized samplers with plates set perpendicular to the direction of flow. Edmunds et al. (1976) reported that ephemerellids occurring in fast flowing waters usually are found in protected crevices in the substrate. This may explain why more ephemerellids were collected with the perpendicular orientation, which provides more crevices protected from the stream flow. More Rhyacophilidae colonized samplers with plates parallel to the flow. Wiggins (1977) noted that rhyacophilids are usually found in high velocity areas. Beckett and Miller (1982) found more hydropsychid larvae on Hester-Dendy samplers from areas of higher velocity. However, we found no significant difference in the colonization of hydropsychid larvae, even though samplers with plates parallel to the water flow should have higher water velocities between the plates than samplers in the perpendicular orientation. Perlidae colonized samplers in the perpendicular orientation only, suggesting they prefer areas protected

Table 1. Mean number of invertebrates collected per sampler with 30 Hester-Dendy samplers oriented parallel or perpendicular to the direction of water flow.

		Parallel to flow		Perpendicular to flow	
Order	Family	$\bar{x}$	SD	$\bar{x}$	SD
Ephemeroptera	Ephemerellidae[1]	1.33	0.21	1.57	0.28
	Heptageniidae	0.83	1.14	0.73	1.33
	Baetidae	13.33	3.64	12.33	3.60
	Leptophlebiidae	0.03	0.18	0.10	0.30
Trichoptera	Hydropsychidae	0.20	0.50	0.17	0.35
	Rhyacophilidae[1]	0.36	0.86	0.20	0.55
Diptera	Simuliidae	1.43	2.60	0.97	1.37
	Chironomidae	4.61	3.01	4.73	2.64
Plecoptera	Perlodidae	2.20	1.76	1.60	1.72
	Peltoperlidae	0.90	1.25	1.00	1.37
	Perlidae[1]	0.00	0.00	1.20	0.48
Coleoptera	Dryopidae	0.07	0.36	0.03	0.30

[1]Significantly different X^2 test, $P < 0.05$.

from water currents.

Structural modifications of Hester-Dendy samplers may influence the effect of sampler orientation on colonization. If the size of alternate plates is reduced or the distance between plates is increased, water velocities between plates will increase for samplers in the parallel orientation. This may lead to even greater differences in invertebrate colonization than we observed.

In summary, for some insect families the orientation of Hester-Dendy samplers to the direction of water flow can have a significant affect on the abundance of macroinvertebrates that colonize them. Uniform orientation of samplers may reduce variability in invertebrate colonization, but alternating orientations may offer a broader range of microhabitats for colonization.

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HERMAPHRODITISM IN THE ROCK SCALLOP, *CRASSADOMA (HINNITES) GIGANTEUS*, IN HUMBOLDT BAY, CALIFORNIA

MARK MALACHOWSKI
Telonicher Marine Laboratory
Trinidad, California 95570

Rock scallops inhabit rocky substrate, both inter- and sub-tidally from northern Alaska to Baja California, Mexico (Young 1951). Wild stocks of rock scallops are harvested for sport (R. Warner, pers. comm.) and this shellfish is considered a potential mariculture species (Leighton and Phleger 1977, Leighton 1981, Cary et al. 1981). As part of a study on the gametogenic cycle of the rock scallop, *Crassadoma giganteus*, one hermaphrodite was found among 115 individuals examined from Humboldt Bay, California. (Malachowski 1988). The only previously reported occurrence of hermaphroditism in rock scallops was by Lauren (1982), who found two in the waters of Puget Sound, Washington.

Examination of 115 rock scallops showed a sex ratio of females to males of 0.6/1.0. There was only one animal in the indifferent stage, observed in June 1985, and one hermaphrodite, observed in August 1984. In the indifferent stage sex cells are not present and sex determination is not possible. A photomicrograph of a gonadal section of the hermaphrodite found is shown in Figure 1. It was the mixed type, where

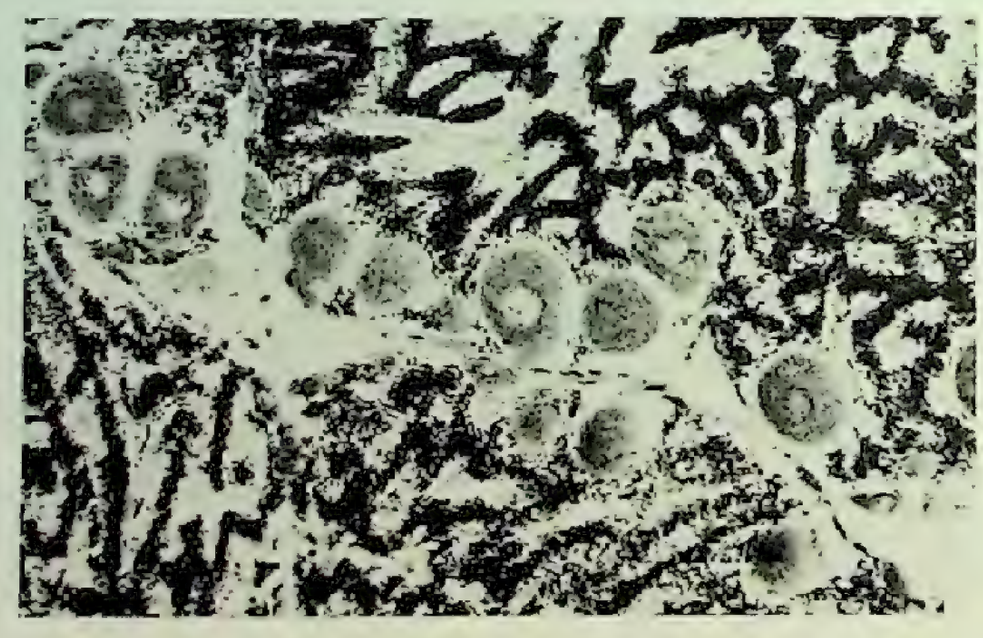

Figure 1. Photomicrograph of gonadal section of hermaphrodite *Crassadoma giganteus* at 200x magnification.

[1] Current Address: 743-17th Ave. Menlo Park, California 94025.

TABLE 1. Statistical analysis of randomly selected male and female scallops *(Crassadoma giganteus)* from naturally occurring populations of Humboldt Bay, California.

	Shell Height (cm)				
	n	$\bar{x}$	SD	SD^2	CV
Females	22	11.41	1.92	3.68	16.83%
Male	16	11.56	2.39	5.73	20.67%
	$t = 0.0779$		$t(0.05) = 2.54$ ns		
	Shell Length (cm)				
	n	$\bar{x}$	SD	SD^2	CV
Females	22	11.22	1.69	2.85	15.06%
Males	16	10.81	1.72	2.96	15.91
	$t = 0.7394$		$t(0.05) = 1.18$ ns		

both male and female gametes are contained within the same follicle (Ropes 1968, Shaw 1970, Otto 1972, Lauren 1982). The female gametes were in the late development stage while the male gametes were fully developed.

Based on two hermaphroditic specimens, Lauren (1982) suggested that protrandry occurs in rock scallops and enhances reproductive success. He hypothesized that since individual males produced a much larger number of gametes than individual females, only a few males would be needed to fertilize a large number of females. If males developed into females as they matured, this would allow a more productive male to female ratio.

Protrandry in rock scallops from Humboldt Bay appears unlikely because: (i) there was not a large disparity in the sex ratio of the scallops collected, (ii) statistical analysis of the equality of means of samples of the two sexes for shell length and height showed no significant difference (Table 1) and, (iii) only one hermaphrodite was found among 115 specimens examined.

Hermaphroditism is rare in bivalves (Merrill and Burch 1960, Naidu 1970, Ropes 1968, Shaw 1970). Based on this study and that of Lauren's (1982), it is also rare in rock scallops. The gonadal development of the male and female components of the hermaphrodites found in both Puget Sound, Washington and in Humboldt Bay was nearly equal. Also, the phases of the hermaprodites corresponded with those of sexually differentiated scallops. This suggests that hermaphrodite spawning is synchronized with the rest of the population and that this phenomena does not have a deleterious affect on reproductive success.

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FALL MIGRATION PATTERNS OF COMMON SNIPE

FRANK EDELMANN
Humboldt State University
Arcata, CA 95521

A discrepancy in the literature occurs regarding differential fall migration timing between common snipe (*Gallinago gallinago*) sexes. Tuck (1972) reported a differential migration from Newfoundland with females migrating in October and males migrating in November. Whitehead (1965) however, reported that males migrated to Louisiana in October while females migrated to Louisiana in November. The purpose of my study was to determine if snipe sexes differentially migrated to and through the Humboldt Bay area in fall and winter.

Understanding migration patterns of game birds is important for evaluating hunting seasons. Differential sex harvest by hunting of an apparently monogamous species (Tuck 1972) such as common snipe, could cause reduced breeding due to a lack of individuals of one sex. Differential sex migration during the fall could cause a differenrtial sex harvest if hunting seasons coincided with the migration of only one sex.

Common snipe were collected in the Humboldt Bay vicinity at Elk River Wildlife Area, 10 km south of Eureka, California by shotgun during the California snipe hunting season of 7 October 1989-21 January 1990. Biases of differential sex harvest in the sampling design were minimized by attempting to harvest all birds seen within range and by the shooter's inability to distinguish sex by sight. The sex of collected birds was determined by necropsy and recorded by date collected.

Sex ratio data were pooled and analyzed by (1) day collected, (2) week collected, (3) month collected (Whitehead 1965), and (4) by migration pulse periods of snipe to the Humboldt Bay area as described by White (1963) (Fig. 1). Chi-square contingency table analysis (Zar 1984) was then conducted for each pooled data set to test the null hypothesis that sex ratio of migrating snipe was independent of time.

One hundred ninety snipe were collected during the study with an overall sex ratio of 1:1 (Fig. 1). This sex ratio did not change ($P > 0.05$) across time for any pooling method. Since each pooling method's analysis gave the same result, I concluded that no differential sex migration occurred over time for snipe in the Humboldt Bay area during the 1989-90 fall migration.

These results, in light of Whitehead's (1965) and Tuck's (1972) findings, may support arguments of randomness, region-specific or breeding population-specific variations in common snipe fall migration timing. Long term studies and large sample sizes of individuals collected and areas sampled, are necessary to obtain a more thorough assessment of common snipe fall migration patterns in North America.

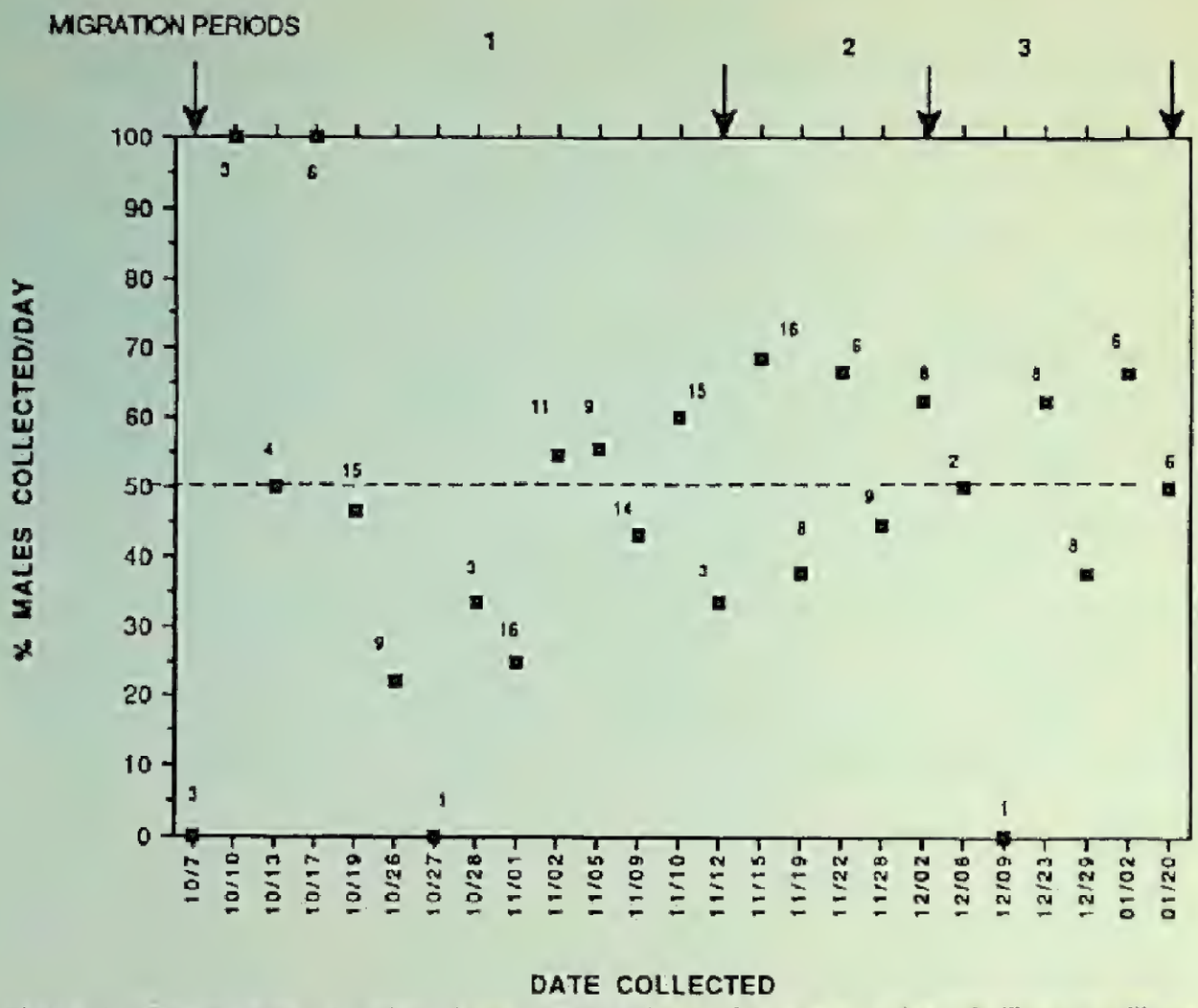

Figure 1. Percentages of males, dates, and numbers of common snipe, *Gallinago gallinago*, collected in the Humboldt Bay area during the 1989-90 California common snipe hunting season.

If fall migration patterns of common snipe are region or population-specific, it may be necessary to set hunting seasons in such a manner to avoid overharvest of one sex and to maintain maximum reproductive output of this species.

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A NEW TOOL FOR SAFELY KILLING VENOMOUS SNAKES IN THE FIELD

MARK R. JENNINGS[1] AND JENS V. VINDUM
Department of Herpetology
California Academy of Sciences
Golden Gate Park, San Francisco, CA 94118

Although the need to conserve our herpetological resources has become increasingly apparent over recent decades (Ashton 1976, Groombridge 1982, Phillips 1990), scientific studies that require the handling and killing of venomous snakes in the field still remain an integral part of the discipline and are a matter of great concern to herpetologists (Pisani 1973, Anonymous 1987). This is especially true when the collection of voucher specimens is necessary. Even when individuals are properly trained, there is always the chance that a person may be bitten and suffer the unpleasant consequences. Additionally, many workers in animal control and fish and wildlife agencies have an aversion to handling snakes, including nonvenomous ones. The following tool can be used by herpetologists and other workers when needed.

It is essential that snakes (or any other herpetological specimens) be killed in such a manner that when preserved they may be conveniently and carefully examined (Pisani 1973). The most common method of killing is by the hypodermic injection of a strong barbituate into the heart, usually aqueous sodium pentobarbital (Nembutal) or hydrous chlorobutanol (Chloretone) (Duellman 1962, Pisani 1973). This has always necessitated holding the specimen while it is injected. The following "snake injecting stick" (Fig. 1) was designed to allow a person to inject a venomous reptile from a safe distance while it is pinned down with snake tongs by one or two assistants.

The snake injecting stick takes about 1 hr to make and costs approximately $4.00 (1991 U.S. dollars). The materials used (Table 1), except the syringe and needle(s), are available from any hardware or building supply store.

Construction of the stick is relatively simple. First shape the handle as shown in Fig. 1, making sure to cut a groove through the top to allow passage of the stiff wire. Next trim off the excess rubber on the base of the electrical spring connectors and screw them on each end of the stiff wire. After this is completed, cut through the sides of the channel aluminum stock to allow inclusion of the syringe handle. The syringe may now be taped into place with electrical tape. Next place the stiff wire in the grooved wooden handle and drill holes through the channel aluminum stock and handle where indicated (Fig. 1). Bolt (or rivet) the handle assembly together and place electrical tape around the channel aluminum stock at the points indicated. The snake injecting stick is now ready for use.

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[1]Research Associate.

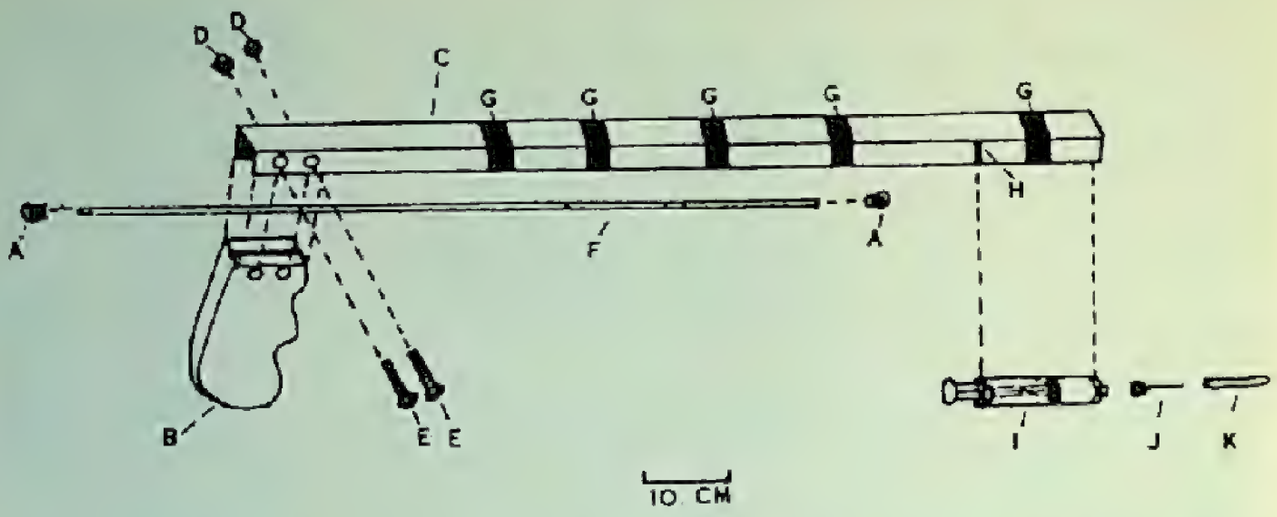

Figure 1. Exploded view of the snake injecting stick showing component parts. Items identified are as follows: (A) electrical spring connectors; (B) wooden handle; (C) channel aluminum stock; (D) nuts; (E) bolts; (F) stiff wire; (G) electrical tape; (H) slit for syringe handle; (I) syringe; (J) needle; and (K) needle cover.

Table 1. Materials used to construct the snake injecting stick.

Amount	Material
1	10.16-cm length of 2.54-cm high X 5.08-cm wide softwood
1	0.91-m section of 1.27-cm wide (flanges are 0.95-cm deep) channel aluminum stock
1	0.86-m length of stiff wire (brazing wire is suitable)
2	0.32-cm diameter X 2.54-cm long bolts with nuts
2	Type "R" electrical spring connectors
1	3 cc plastic syringe with a 2.54-cm long 20 gage needle
1	Roll of 1.27-cm wide electrical tape

To inject the snake, one or two assistants pin the snake on the ground with snake tongs (e.g., Manco Inc., Eldon, MO) or snake hooks (e.g., Fuhrman Diversified, Seabrook, TX) so the specimen is more or less stretched out. The person doing the injecting loads the syringe with the killing agent and then injects the snake as near to the heart as possible. Injecting can be accomplished quickly if the thumb rapidly pushes the electrical spring connector on the end of the stiff wire. It generally takes from a few seconds to a minute for the killing agent to take effect. Once the snake is anesthetized or dead it is placed by the use of tongs in a plastic 3.785-l plastic jar or other suitable container and securely covered. Fixative maybe injected or added at this time, or later depending on final disposition of the specimen.

We prefer to carry the snake injecting stick in the field without the needle attached. Needles can be safely carried in their protective converings in a kit along with the killing agent. The needle can be attached just before the killing agent is drawn into the syringe. In all cases, care is taken to follow safety procedures in using dangerous chemicals. We have found that T-61 Euthanasia Solution (American

Hoechst Corporation, Animal Health Division, Somerville, NJ) is an effective killing agent. One cc of T-61 is sufficient to kill a 1-m long rattlesnake.

This technique of injecting snakes has limitations. Large snakes over 1 m in length may be difficult to pin down and stretch out under certain situations. In such cases, we have found that an injection at the base of the skull almost immediately disables the snake so a second injection can be made in the heart. Additionally, if the snake moves suddenly during injection, the syringe needle could be bent or broken. We have found that injecting the snake next to where it is constrained with tongs eliminates this hazard. Persons using this method should also be aware of laws related to the use and possession of syringes and killing agents because they are closely regulated by the Federal Bureau of Narcotics as dangerous drugs. The snake injecting stick is an effective tool when used properly. We have taken over 50 rattlesnakes (6 species) ranging in size from 0.3-1.5 m with this device during the past decade from a variety of habitats in California and Arizona.

The snake injecting stick is simple, inexpensive to make, lightweight, and easy to repair if broken. Its use allows herpetologists and other professionals the opportunity to obtain specimens of venomous snakes with a relatively high degree of safety.

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NORTHERN RANGE EXTENSION FOR THE ZEBRAPERCH (*Hermosilla azurea*, Jenkins and Evermann)

RON FRITZSCHE, GEIR AASEN, LOREN EVEREST,
PAUL PETROS, AND STEVE SHIMEK
Department of Fisheries
Humboldt State University
Arcata, CA 95521

On 15 August 1985, a zebraperch (*Hermosilla azurea*) was collected in Northern California in the Klamath River Estuary (41° 31.5'N., 124° 05.7'W.) during a U.S. Fish and Wildlife Service (USFWS) beach seining operation. The specimen (HSU 86-27) measured 270 mm SL, but only the head was saved. Two additional specimens were collected in the Klamath River Estuary during USFWS beach seining operations on 10 August 1987 (specimen discarded by USFWS after being recorded), and on 22 September 1988 (HSU 88-2, 238 mm SL).

The zebraperch was first described from specimens collected off Guaymas, Mexico (Jenkins and Evermann 1888). Phillips (1965) collected 40 specimens off Monterey Bay, California to extend the range northward from Santa Monica Bay. Stevens et al. (1989) list the range as Monterey Bay, California, to the Gulf of California. They also point out that zebraperch prefer warm waters and are rare north of southern California. The collections reported here extend the known range approximately 560 km northward.

The zebraperch is a member of the family Kyphosidae. Being laterally compressed it superficially resembles the surfperches (Embiotocidae) but can be separated by meristic counts. Meristic data for the only complete specimen (HSU 88-2) are as follows: D XI,11; A III,10; GR 7+11. A lateral line scale count was not possible due to scales missing from the caudal peduncle. The body of this specimen is dusky brown above and whitish below with 12 faint bars along the side. A dark spot is present on the operculum and a double sheath of fine scales is present along the base of the dorsal fin.

Northern range extensions along the California coast for marine fishes are not uncommon following periods of warm water associated with El Nino events. Pearcy and Schoener (1987) list nine fishes (*Remora remora, Synodus lucioceps, Echinorhinus cookei, Chilara taylori, Pristigenys serrula, Xiphias gladius, Symphurus atricauda, Balistes polylepis*, and *Melichthys niger*) collected north of their recorded ranges into waters off Oregon to Alaska following the very strong 1982-1983 El Nino. Lea et al. (1989) document the occurrence of the Cortez angelfish (*Pomacanthus zonipectus*) at three localities off southern California between March 1984 and October 1986. They also review the records of eastern tropical Pacific or Indo-West Pacific fishes known from a single or only a few records for California. The zebrafish collected from the Klamath River Estuary may represent individuals that moved northward

during the strong 1982-1983 El Nino. These fishes may then have found refuge in the Klamath River Estuary with the return of colder water following the El Nino.

ACKNOWLEDGMENTS

We are grateful to Tom Kisanuki of the USFWS, Arcata for bringing our attention to these specimens and providing access to his records.

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MISCELLANEA

"THE GOOD OLD DAYS."- As far as abundance of game is concerned, we can certainly point to "the good old days" as being better than the present. We recently saw a letter which made the statement that in the season (September 15-March 15), 1882-1883, two men, shooting for the market six days each week, killed 27,000 ducks. This record shoot took place in the Sacramento Valley. Every one conversant with the conditions at the present time will willingly concede that no such shoot as this is possible anywhere in the state at the present time. The writer of the letter, himself one of the hunters, is now a game conservationist and is very much opposed to even the smaller slaughter of game by market hunters at the present time.

We wish that we were able to place in front of our readers exact figures as to former kills and those possible at the present time. We believe that such figures would be convincing proof of the immediate need for the better protection of our game birds and mammals.—*H.C. Bryant, Volume 1(2)- January 1915.*

RARE FISH FROM MONTEREY BAY. The true halibut (*Hippoglossus hippoglossus*) was occasionally taken this last summer (1918) in Monterey Bay. It has not been reported before south of San Francisco.—*E.C. Starks, Volume 5(1)- January 1919.*

Plants of Golden trout were made in the Santa Ana River, San Bernardino County, and in Mammoth Creek and Convict Lake, Mono County. A shipment of golden trout was planted in Lake Tahoe, and a consignment sent to Mount Shasta Hatchery to be liberated in the McCloud River at a later date.—*W.H. Shebley, Volume 5(1)- January 1919.*

RESEARCH PROBLEMS OF THE CALIFORNIA FISH AND GAME COMMISSION. Although depending largely on the results of scientific investigations carried on by universities and professional investigators, the California Fish and Game Commission is actively engaged in solving some of the problems connected with the administration of fish and game resources. The greater the basis of fact the more sure is proper legislation. Facts suitable as a basis for legislation are obtained by careful research work. Some of the early experiments in tagging salmon and trout furnished dependable evidence as to the importance of these fish and furnished a splendid basis for legislation. Experiments carried out by the state hatcheries have greatly improved methods.

A summary of the investigations now under way will demonstrate the fact that the commission is attacking problems in a systematic and scientific way.—*H.C. Bryant, Volume 4(3)- July 1919.*

INSTRUCTIONS FOR CONTRIBUTORS

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